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MAXIMIZING ROOT DEVELOPMENT FOR ENHANCED SURVIVAL AND ESTABLISHMENT OF NEWLY-TRANSPLANTED SASKATOONS

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Maximizing Root Development For Enhanced Survival And Establishment Of Newly-transplanted Saskatoons

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1. ABSTRACT/SUMMARY

Saskatoon transplant survival and growth are affected by site, cultivar, propagation method, state of dormancy, transplant type, transplanting date, and mulch type. Sites characterized by poor weed control, too little irrigation, no wind protection, and rodent damage have a substantial negative impact on successful transplant establishment. The cultivar Smoky showed higher survival rates and greater growth compared to the cultivars Northline and Thiessen, but survival and growth of all three cultivars were acceptable. Growth of seedling transplants was greater than micropropagated transplants. The practice of sizing up micropropagated plant material in a greenhouse prior to spring sale may contribute to post-transplant shock. Transplants allowed to break dormancy in early-May appear to be less prone to transplant shock than transplants that are forced out of dormancy in March. Growers should delay or avoid planting material that appears to be under stress, especially at sites where growing conditions are not optimal. Bare-root transplants performed more poorly than plug transplants. Handling of the root system prior to transplanting appears to have a negative impact on transplant establishment. Early-season planting dates increased transplant survival and growth; July and August transplant dates should be avoided. Fall planting is acceptable, but growers should be certain that plants are of superior quality, fully hardened-off and any post-planting stress must be avoided. The use of black plastic mulch increased growth, but tended to decrease survival. However, black plastic mulch substantially reduces weed management during the first 2-3 years of orchard establishment.

2. EXECUTIVE SUMMARY

The objective of this project was to determine the effects of site, cultivar, propagation method, state of dormancy, transplant type, transplanting date, and mulch type on survival and growth of saskatoon transplants. The information derived from this activity is important to the

successful propagation of plant material, the establishment of orchards with minimal plant loss, and the management of growth and development so as to maximize plant vigour and yield at an earlier age, thus reducing costs of production.

This project involved the use of three study sites: a) the University of Saskatchewan (UofS) Department of Plant Sciences' Horticultural Field Plots in Saskatoon; b) a grower-co-operator site at Keeler, SK; and c) the Canada-Saskatchewan Irrigation Diversification Centre in Outlook, SK. Four experimental trials were conducted to meet the objectives of this project. Two trials, associated with investigations of the effects of a) propagation method and cultivar, and b) transplant type, transplanting date and mulch type, were planted at each of the UofS and Keeler sites. Only the trial associated with the effects of transplant type, transplanting date, and mulch type was established at Outlook. The final experimental trial, associated with an investigation of the effects of the state of dormancy on transplants, was conducted at the UofS. All data collection was carried out during the 2000 and 2001 growing seasons.

The results of the four experiments that comprised this study indicated that saskatoon transplant survival and growth are affected by site, cultivar, state of dormancy, propagation method, transplant type, transplanting date, and mulch type.

Site can have a substantial impact on transplant performance. Site differences appeared to be associated with weed management practices, irrigation practices, protection from the wind, and rodent damage. Weedy, windy, moisture-stressed sites (conditions typical of the Keeler location) have a negative impact on transplant success.

The cultivar Smoky generally showed higher fall survival and greater growth when compared to the cultivar Thiessen. The growth and fall survival of the cultivar Northline usually fell between the cultivars Thiessen and Smoky. However, in general, the fall survival and growth of all three of the cultivars were acceptable.

Growth of the seedling transplants generally was greater than that of the micropropagated transplants. The common practice of sizing up micropropagated plant material in a greenhouse prior to spring sale may contribute to the post-transplant shock that was observed. Since there were obvious differences in transplant quality and growth stage associated with these two propagation methods, more work is needed to differentiate between the effect of propagation method and general transplant quality. Limited data suggest that transplants which are allowed to break dormancy during early-May are less prone to transplant shock and tend to grow better than transplants that are forced out of dormancy in March. These observations demonstrate a need to develop quality standards for saskatoon transplants. Growers should delay or avoid planting material that appears to be under stress. This is particularly important at sites where growing conditions are not optimal.

Bare-root transplants performed more poorly than plug transplants. It is possible that damage to the roots occurred during the procedure used to create the bare-root stock, and this had a negative impact on plant growth and survival. These results suggest that handling of the root system prior to transplanting could have a negative impact on transplant establishment.

Early-season planting dates resulted in increased transplant survival compared with late-season planting periods. There is a greater risk of poor transplant survival if planting occurs after the end of June. The experiments indicate that July and August plantings should be avoided. It is possible that the practice of increasing transplant size by breaking dormancy several months early places too much stress on transplants for successful late-season plantings. Fall planting is a common practice that generally provides satisfactory results, but growers should be certain that plants are of superior quality, fully hardened-off and any post-planting stress must be avoided.

The use of black plastic mulch increased soil temperature and increased plant growth. However, the use of black plastic mulch tended to have a negative impact on transplant survival, especially if transplanting occurred in July or August. Stresses associated with the application and use of black plastic mulch include damage that can occur during mulch application overtop of the transplants, and more frequently, when plants are pulled through the plastic after the mulch is applied. After the first winter, sunscald was noted on many of the transplants in the black plastic mulch treatments, which could have contributed to reduced fall survival in this group. If dieback occurs where plastic mulch is used, it is important to check for new growth and redirect it through the slit in the plastic mulch to prevent further setback of the plant material. It is possible that a different color of plastic mulch would have produced different effects. It's important to note that black plastic mulch substantially reduces the weed management required during the first 2-3 years of orchard establishment.

3. TECHNICAL REPORT

3.1. Background

The objective of this project was to determine the effects of site, cultivar, propagation method, state of dormancy, transplant type, transplanting date, and mulch type on survival and growth of saskatoon transplants. The information derived from this activity is important to the successful propagation of plant material, the establishment of orchards with minimal plant loss, and the management of growth and development so as to maximize plant vigour and yield at an earlier age, thus reducing costs of production.

Progress in the further development of the native fruit industry in Saskatchewan is impeded by a number of factors including a poor understanding of what factors influence the survival, successful establishment, and growth and vigour of native fruit species, and consequently, ill-defined management practices. In order to improve management practices so as to produce earlier and consistent fruit yields, it is necessary to determine what factors influence the survival, successful establishment, and growth and vigour of native fruit species. The information derived from this activity is important to the successful propagation of plant material, the establishment of orchards with minimal plant loss, and the management of growth and development so as to maximize plant vigour and yield at an earlier age, and thus grower's profits.

3.2. Materials and Methods

3.2.1. Study Sites

This project involved the use of three study sites: a) the University of Saskatchewan (UofS) Department of Plant Sciences' Horticultural Field Plots in Saskatoon (Figure 3.2.1); b) a grower-co-operator site at Keeler, SK (Figure 3.2.2); and c) the Canada-Saskatchewan Irrigation Diversification Centre in Outlook, SK.

3.2.2. Experiments Conducted

Four experimental trials were conducted to meet the objectives of this project. Two trials, associated with investigations of the effects of a) propagation method and cultivar, and b) transplant type, transplanting date and mulch type, were planted at each of the UofS and Keeler sites. Only the trial associated with the effects of transplant type, transplanting date, and mulch type, was established at Outlook. The final experimental trial, associated with an investigation of the effects of the state of dormancy on transplants, was conducted at the UofS. All data collection was carried out during the 2000 and 2001 growing seasons.

3.2.2.1. Effects of Propagation Method and Cultivar on Transplant Survival and Growth

Seedlings and micropropagated plant material of the cultivars Smoky, Thiessen, and Northline were used in this experiment. The experimental design was a 2X2X3 factorial of propagation method X site X cultivar. Treatments consisting of five plants each were transplanted into field trials using a randomized complete block design with four replicates. A 1 meter plant spacing, 2 meter treatment spacing and 4.5 meter row spacing were used for this experiment. The experiment was established on May 31, 1999 at the U of S and on June 1, 1999 at Keeler.

3.2.2.2. Effects of Transplant Type, Transplanting Date, and Mulch Type on Plant Survival and Growth

Micropropagated plants of the cultivar Smoky were used for this experiment (Figure 3.2.1). The experimental design was a 2X5X3X2 randomized complete block factorial of transplant type, transplanting date, mulch type, and site, with 3 replicates. Treatments consisting of 4 plants each were transplanted into the field over the course of the five transplanting dates. A 0.75 meter plant spacing, 1.75 meter treatment spacing and 3 meter row spacing was used in this experiment. Row spacing at the grower-managed site was increased to 5 meters in order to match the existing row spacing in the rest of the orchard. This experiment was established at the UofS and Keeler sites during the 1999 season. A third trial was established at the Outlook site, except that only two mulch types were used, and each treatment consisted of 5 plants each.

The two transplant types were the standard peatmoss root plug, and bare-root. The bare-root material was obtained by carefully washing the medium from the roots prior to transplanting.

The transplant dates were late-May, late-June, late-July, late-August and late-September. Plant material for the last 4 plantings was transplanted into 1 gallon pots containing Sunshine #4 potting medium. The potting medium was amended with 2.5 g/litre of Plant Products Nutricote 18-6-8 type 70 time-release fertilizer to avoid nutrient deficiencies during the growing season.

Three mulch types were applied in this trial. These included a bare-soil control (no mulch), black plastic mulch, and a wood chip mulch (Figures 3.2.3 to 3.2.5). The black plastic mulch was applied by hand overtop of the saskatoon transplants. Holes were then cut in the mulch and the plant shoots were carefully pulled through the plastic. Transplants receiving the wood chip mulch treatment were transplanted into a shallow trench and then covered with approximately 20 cm of poplar wood chips. Only the black plastic mulch treatment was applied at the Outlook site, along with a control.

Both sites were drip irrigated. Buried supply lines and surface lateral lines were installed at each site prior to the establishment of the experiments (Figure 3.2.2). One gallon per hour emitters were used at both sites. Emitters were installed by hand at transplanting time and were placed approximately 10 cm from each transplant. During the first growing season, irrigation was applied for 1 hour intervals, 3 times per week during warm, dry weather. However, significant rainfall limited the need for irrigation during the first season.

Soil moisture, and air and soil temperatures were measured at 15cm and 30 cm below the soil surface. Hourly soil temperature and soil moisture readings were recorded using Spectrum Technologies, Inc. Model 450 WatchDog™data loggers. Datalogger malfunction resulted in an unusable data set for the 2000 season at both sites, and for the 2001 season at Keeler. Soil moisture and temperature data were successfully collected at the University of Saskatchewan site during the 2001 season.

Orthene was applied at the study sites to control woolly elm aphid infestations.

3.2.2.3. Effects of the State of Dormancy on Saskatoon Survival and Growth

Since the practice of forcing transplants out of dormancy during late winter may have contributed to the transplant shock and poor establishment observed in these trials, an experiment was initiated during 2000/2001 to compare the performance of saskatoon transplants forced out of dormancy in March (a common practice used by propagators to increase plant size prior to sale), to those allowed to break dormancy naturally in early-May. For this study, micropropagated saskatoon transplants of the cultivar Smoky were obtained from D'nA Gardens, Elnora, AB, during the fall of 2000 and were placed in a 0°C cooler. Half of the transplants were removed from the cooler during March 2001 and grown in a greenhouse until mid-May when they were moved to a shadehouse to harden-off. At this time, the remaining transplants were removed from the cooler and were placed in the same shadehouse. The experimental design was

a 2X5 randomized complete block factorial of state of dormancy and transplanting date, with 3 replicates of 5 plants each. Five transplanting periods (late-May, late-June, late-July, late-August and late-September) were used. Plants that were not used for the May planting treatment were transplanted to 1 gallon pots containing commercial potting mix (Sunshine #4). All transplants were fertilized using dilute 20-20-20 liquid fertilizer (PlantProd) from the point of bud-break until mid-July. Once in the field, transplants were irrigated using trickle irrigation and were covered with black plastic mulch immediately following transplanting.

3.2.3. Data Collection and Statistical Analysis

The following data were collected, depending on experiment:
Spring Survival – the number of plants surviving in each treatment, expressed as a percentage; observations were made in the month of May.
Fall Survival – the number of plants surviving in each treatment expressed as a percentage; observations were made in the month of September.
Mean Height/Plant – distance from soil level to the end of the tallest shoot tip; this measurement was taken from the original transplant only, not from suckers.
Mean Number of Branches/Plant – the number of branches of the main stem of the transplant. This value does not include second and higher order branches.
Mean New Growth/Plant – the amount of new growth originating from the main stem of the transplant.
Mean Number of Suckers/Plant – the average number of suckers per plant.
Mean Cumulative Sucker Length/Plant – the sum of the lengths of all the suckers produced in the treatment divided by the number of plants in the treatment.
Mean Sucker Length/Plant – the average length of the suckers produced per plant.
Mean Stem Caliper/Plant – the diameter of the main stem 3 cm above the soil surface.
Mean Number of Flowers/Plant - the average number of flowers produced per plant in the treatment.
Mean Dry Shoot Weight/Plant – the average weight per plant of above-ground biomass that has been dried in a drying oven to remove all the water from the plant material.
Mean Treatment Shoot Weight (fresh) – the weight of all the above-ground biomass from a treatment prior to being dried in a drying oven.
Mean Treatment Shoot Weight (dry) - the weight of all the above-ground biomass from a treatment that has been dried in a drying oven to remove all the water from the plant material.
Mean Surviving Shoot Weight/Plant (fresh and dry) – the average weight of the surviving plants in a treatment (fresh or dried).
Mean Shoot Weight (fresh and dry) – the weight of all the above ground biomass from the treatment divided by 5 (the number of plants originally planted in each treatment).

At the end of the 2000 growing season at the Outlook site, and at the end of the 2001 growing season at the UofS and Keeler sites, plants were undercut and harvested. At this time, fall survival and shoot weight data were collected. It was not possible to harvest the roots successfully, therefore root growth data were not collected.

Data were analyzed using the SAS GLM procedure. Significant treatment means were compared using the LSD in 2000 and LSMEANS in 2001.

3.3. Results and Discussion

3.3.1. Effects of Propagation Method and Cultivar on Transplant Survival and Growth

The results of the ANOVA for the data collected in the 2000 growing season indicated that transplant growth was significantly affected by propagation method, cultivar and site (Tables 3.3.1.1 through 3.3.1.3).

Seedling transplants had significantly greater heights, new growth, number of branches, number of suckers, and sucker growth and length compared to micropropagated transplants (Table 3.3.1.1 and Figure 3.3.1.1). It appeared that transplant quality was the primary reason for these differences. The seedling transplants were dormant at planting time and did not exhibit symptoms of transplant shock after planting. The micropropagated plants were actively growing at delivery and had been in a greenhouse for several months prior to shipping. A significant portion of the micropropagated plants began to suffer from shock approximately one week after being placed in a shadehouse for hardening-off. The supplier was contacted regarding this problem but a precise cause or solution was not determined. These plants were used in this trial since replacements could not be obtained. The vendors of both transplant groups categorized their plants in the same height group (30-45 cm), however the seedling group was dormant so this measurement did not include any new growth.

Plants grown at the UofS site were taller, had more branches, and more, longer suckers (Table 3.3.1.2). There was a significant amount of rodent damage observed during the fall of 1999 at the Keeler site, which may have contributed to this result.

The cultivar Smoky had more new growth and produced longer suckers than the other cultivars. The cultivar Smoky also had greater fall survival, number of branches and number of suckers than the cultivar Thiessen. The cultivar Thiessen produced fewer suckers than the other cultivars. The cultivar Smoky consistently showed greater fall survival and growth when compared with the cultivar Thiessen. The growth and fall survival of the cultivar Northline generally fell between the cultivars Thiessen and Smoky (Table 3.3.1.3). In general, the fall survival and growth of all three of the cultivars were acceptable.

The results of the ANOVA for the data collected in the 2001 growing season indicated that transplant growth was significantly affected by the interactions of site and cultivar, site and propagation method, cultivar and propagation method, and site, propagation method and cultivar (Tables 3.3.1.4. through 3.3.1.7).

The mean number of suckers/transplant varied depending on site, cultivar, and propagation method. All the cultivars at the University of Saskatchewan site produced more suckers than those at Keeler (Table 3.3.1.4). This likely was the result of more difficult growing conditions at the Keeler location. At the University of Saskatchewan, the cultivars Smoky and

Northline produced approximately twice as many suckers as the cultivar Thiessen. At both sites, the seedling transplants produced more suckers then transplants produced via micropropagation (Table 3.3.1.5). Amongst seedling transplants, the cultivar Smoky produced the greatest number of suckers/transplant, whereas Thiessen seedlings produced the least number. Micropropagated Northline transplants produced the most number of suckers/transplant, whereas micropropagated Thiessen transplants produced the least (Table 3.3.1.6).

None of the micropropagated plants produced any flowers during the course of this experiment. Seedling Smoky transplants flowered during the 2001 season (Figure 3.3.1.2). Only a very few plants of the other cultivars tested in the seedling group flowered (Table 3.3.1.6).

Stem caliper, plant height, cumulative sucker length, and mean sucker length varied with site, propagation method and cultivar (Table 3.3.1.7). At the Keeler site, where growing conditions were less favorable, seedling transplants of the cultivar Smoky performed much better in terms of stem caliper, height and sucker growth compared to seedling and micropropagated transplants of the other cultivars. At the University of Saskatchewan, seedling Smoky and Northline transplants had the longest suckers. Average sucker length was least in the micropropagated transplants. The tallest transplants generally were found in the seedling group at the University of Saskatchewan. Of the micropropagated transplants, the cultivar Smoky had the greatest plant height.

In general, the results of this experiment indicated that the seedling transplants performed better than the micropropagated transplants. It should be noted that transplant stress in all the micropropagated plants transplanted in 1999 had a generally negative effect on fall survival and growth. Based on these observations, it is suggested that growers delay or avoid planting material that appears to be under stress. Site can have a substantial impact on transplant performance. Weedy, windy, moisture-stressed sites (conditions typical of the Keeler location) have a negative impact on transplant success. Transplant growth also varies with cultivar. The cultivar Smoky generally tended to produce more growth at both sites in the two years that data were collected, than did the cultivars Northline and Thiessen.

3.3.2. Effects of Transplant Type, Transplanting Date, and Mulch Type on Plant Survival and Growth – UofS and Keeler Sites

The results of the ANOVA for the data collected in the 2000 growing season indicated that transplant survival and growth were significantly affected by transplant type, site, mulch type, and transplanting date (Tables 3.3.2.1 through 3.3.2.4).

The bare-root transplants under-performed the plug transplants for every variable measured except spring survival (Table 3.3.2.1). Since bare-root saskatoon transplants are not available in the nursery industry, this treatment was created by manually removing medium from plug transplants. It is possible that damage to the roots occurred during this procedure and that this had a negative impact on plant growth and survival. These results suggest that handling of the root system prior to transplanting has a negative impact on transplant establishment.

Only spring survival, transplant height, and branch number varied with site. Transplants at the UofS site outperformed those at the Keeler site in terms of these variables (Table 3.3.2.2). Extensive rodent damage at the Keeler location may help explain these differences. The higher spring survival rate at the UofS may reflect reduced transplant stress from more rigorous weed management practices and also that this location was more sheltered than the Keeler site.

All growth variables differed with respect to mulch type (Table 3.3.2.3). The use of black plastic mulch resulted in lower transplant survival but had a positive effect on new growth, height and branch number. Stresses associated with plastic mulch include damage that can occur during the application of mulch overtop of the transplants, and more frequently, when plants are pulled through the plastic after the mulch is applied. After the first winter, sunscald was noted on transplants in many of the black plastic mulch treatments, which could have contributed to reduced fall survival in this group. It is possible that a different color of plastic mulch would have produced different effects. When weighing the risks and benefits of black plastic mulch, it should be recognized that plastic mulch substantially reduces the weed management required during the first 2-3 years of orchard establishment. A decrease in suckering was apparent in the wood chip mulch. This may be the result of suckers being hidden in the wood chips and not an actual reduction in sucker number.

Transplant survival, and all growth variables differed with respect to transplanting date (Table 3.3.2.4). End-of-season survival was greatest for the May and June transplanting dates (76 and 77% respectively), followed by the September transplanting date (53%). The lowest transplant survival occurred during the July (33%) and August (26%) transplanting dates. The fall survival data from both studies indicate that July and August transplanting should be avoided. The June transplanting often resulted in greater growth than the May transplanting period. Fall transplanting is a common practice that generally provides satisfactory results. If fall transplanting is to be practiced, than growers should be certain that plants are of superior quality, fully hardened-off and any post-planting stress must be avoided. In terms of transplant growth, the combined stress of harsh field conditions, particularly at Keeler, and the shock of being removed from the greenhouse possibly set back growth in the May transplanting group. Also, in terms of plant growth, there was no clear benefit of growing plants in containers during the season relative to planting directly in the field during May or June.

The results of the ANOVA for the data collected in the 2001 growing season indicated that transplant survival and growth were significantly affected by mulch type, site, and the interactions of site and transplant type, site and transplanting date, mulch type and transplanting date, and transplant type and transplanting date (Tables 3.3.2.5. through 3.3.2.10).

Transplant survival was reduced under plastic mulch (Table 3.3.2.5), but plant height was greater. Transplants grown at the UofS generally were twice as tall as those grown at Keeler, and there was a substantial increase in the number of branches in transplants grown at the UofS (Table 3.3.2.6).

At both sites, the bare-root transplants were shorter than transplants grown in their original root plug. At the UofS, bare-root plants were also taller than both transplant types from

Keeler. Transplants with root plugs produced the greatest height (a mean of 47.5 cm) at the UofS; bare-root transplants were shortest (a mean of 16.7 cm) at Keeler (Table 3.3.2.7).

In very large part, transplants at the UofS site had a greater fall survival rate and produced more branches and shoot biomass than transplants at the Keeler site (Table 3.3.2.8). The highest fall survival rate was for transplants at the UofS site planted in May (90.3%); the lowest fall survival rate was at the UofS site for transplanting in July (22.2%). In general, transplanting in the months of May, June and September gave the highest fall survival rates. Similarly, branch production and total dry shoot weight was greatest for transplants that were planted in these months. In terms of shoot biomass production, transplants at the UofS site performed far better than those at the Keeler site. Excessive weed competition at Keeler resulted in very small plants that were very difficult to locate during data collection.

The effects of mulch type varied with transplanting date (Table 3.3.2.9). The highest fall survival rate (91.7%) was for the combined treatment of no mulch and transplanting in the month of June. The lowest fall survival rate (20.8%) was for the combined treatment of plastic mulch and transplanting in the month of August. The best fall survival rates were for transplanting in the month of June, followed by the month of May and then September, regardless of mulch type. The greatest growth of suckers occurred in transplants mulched with black plastic.

Transplant growth in height varied with the combined treatments of transplant type and date of transplanting (Table 3.3.2.10). In very large part, the bare-root transplants were shorter than the plug transplants. Of the plug transplants, those planted in May were the shortest.

The impact of the mulch treatments on soil temperature and soil moisture was measured at 15cm and 30 cm below the soil surface. Daily means of soil temperature and soil moisture are illustrated in Figures 3.3.2.1 through 3.3.2.3. The sensors placed 15 cm below the plastic and woodchip mulch malfunctioned several times during the summer (Figure 3.3.2.1). However, the data collected during May and June (Figure 3.3.2.2) indicated that the woodchip mulch reduced soil temperature and the black plastic increased soil temperature. The temperature data collected at the 30cm depth showed a similar response to the mulch treatments (Figure 3.3.2.3). At this depth, the warming effect of the plastic mulch was greatest during July and August. Soil moisture readings were generally similar among the mulch treatments as long as irrigation was being applied (Figures 3.3.2.4 and 3.3.2.5). Soil moisture began to drop at the 15cm depth after September 15th when the irrigation system was shut off. The loss of soil moisture was less rapid under the woodchip mulch. At the 30 cm depth, several sharp declines in soil moisture were observed in the plastic mulch treatment during the month of August, but the cause of these is unknown. Increased soil temperatures under black plastic mulch enhanced growth but may have decreased fall survival following transplanting.

In general, the results of this experiment indicated that, in terms of survival and growth: a) transplants in root plugs outperformed bare-root transplants; b) transplants at the UofS site outperformed those at the Keeler site; c) transplanting in June, May and September was more successful than transplanting in July or August; and d) the use of plastic mulch enhanced transplant growth, but decreased transplant survival, compared to the use of wood chip mulch, or

no mulch. In regards to this last point, it's important to note that after data collection was completed during the clean-up of the field sites in the fall, some plants were found surviving underneath the plastic mulch. It is possible that transplant survival where plastic mulch was used could have been enhanced if these plants were detected earlier and redirected through the slit in the mulch.

3.3.3. Effects of Transplant Type, Transplanting Date, and Mulch Type on Plant Survival and Growth – Outlook Site

The results of the ANOVA for the data collected in the 2000 growing season at the Outlook site indicated that transplant survival and growth were significantly affected by transplant type, mulch type and transplanting date (Tables 3.3.3.1 through 3.3.2.3). Transplants in root plugs produced greater shoot growth than bare-root transplants (Table 3.3.3.1). There were no statistically significant differences between the black plastic mulch treatments and the control (Table 3.3.3.2). Fall survival rates and growth were highest in the May and June plantings, almost double those in July, August and September, and growth was about 2 to 3 times greater (Table 3.3.3.3).

3.3.4. Effects of Method of Breaking Dormancy on Saskatoon Survival and Growth

Initial observations suggest that transplants that are allowed to break dormancy during early-May are less prone to transplant shock than transplants which are forced out of dormancy in March (Figures 3.3.5.1 and 3.3.5.2). The results of the ANOVA for the data collected in the 2001 growing season at the UofS indicated that transplant survival and growth were significantly affected by the interaction of state of dormancy and transplanting date (Tables 3.3.4.1). Fall survival was lowest for the dormant material planted in May (62.5%). There were no differences in fall survival among the other treatment groups. Dormant material tended to grow more, regardless of transplanting date. Transplant height and growth were greatest among the dormant transplants planted in August and September, and lowest in the dormant material transplanted in May. However, these data are limited to one site and a single year of collection. More work is needed to better understand the impact the propagator's crop management practices on transplant establishment.

4. Conclusions

The results of the four experiments that comprised this study indicated that saskatoon transplant survival and growth are affected by site, cultivar, state of dormancy, propagation method, transplant type, transplanting date, and mulch type.

Site can have a substantial impact on transplant performance. Site differences appeared to be associated with weed management practices, irrigation practices, protection from the wind, and rodent damage. Weedy, windy, moisture-stressed sites (conditions typical of the Keeler location) have a negative impact on transplant success.

The cultivar Smoky generally showed greater fall survival and growth when compared to the cultivar Thiessen. The growth and fall survival of the cultivar Northline usually fell between the cultivars Thiessen and Smoky. However, in general, the fall survival and growth of all three of the cultivars were acceptable.

Growth of the seedling transplants generally was greater than that of the micropropagated transplants. The common practice of sizing up micropropagated plant material in a greenhouse prior to spring sale may contribute to the post-transplant shock that was observed. Since there were obvious differences in transplant quality and growth stage associated with these two propagation methods, more work is needed to differentiate between the effect of propagation method and general transplant quality. Limited data suggest that transplants that are allowed to break dormancy during early-May are less prone to transplant shock and tend to grow better than transplants that are forced out of dormancy in March. These observations demonstrate a need to develop quality standards for saskatoon transplants. Growers should delay or avoid planting material that appears to be under stress. This is particularly important at sites where growing conditions are not optimal.

Bare-root transplants performed more poorly than plug transplants. It is possible that damage to the roots occurred during the procedure used to create the bare-root stock, and this had a negative impact on plant growth and survival. These results suggest that handling of the root system prior to transplanting could have a negative impact on transplant establishment.

Early-season planting dates resulted in increased transplant survival compared with late-season planting periods. There is a greater risk of poor transplant survival if planting occurs after the end of June. The experiments indicate that July and August plantings should be avoided. It is possible that the practice of increasing transplant size by breaking dormancy several months early places too much stress on transplants for successful late-season plantings. Fall planting is a common practice that generally provides satisfactory results, but growers should be certain that plants are of superior quality, fully hardened-off and any post-planting stress must be avoided.

The use of black plastic mulch increased soil temperature and increased plant growth. However, the use of black plastic mulch tended to have a negative impact on transplant survival, especially if transplanting occurred in July or August. Stresses associated with the application and use of black plastic mulch include damage that can occur during mulch application overtop of the transplants, and more frequently, when plants are pulled through the plastic after the mulch is applied. After the first winter, sunscald was noted on many of the transplants in the black plastic mulch treatments, which could have contributed to reduced fall survival in this group. If dieback occurs where plastic mulch is used, it is important to check for new growth and to redirect it through the slit in the plastic mulch to prevent further setback of plant material. It is possible that a different color of plastic mulch would have produced different effects. It's important to note that black plastic mulch substantially reduces the weed management required during the first 2-3 years of orchard establishment.

Table 3.3.1.1. Effect Of Propagation Method On Survival And Growth Of Saskatoon Transplants, Keeler & UofS, 2000.

Propagation Method	Fall Survival %	Mean Height/Plant (cm)	Mean Number of Branches/Plant	Mean New Growth/Plant (cm)	Mean Number of Suckers/Plant	Mean Cumulative Sucker Length/Plant (cm)	Mean Sucker Length/Plant (cm)
Seedling	92.5 a	31.9 a	3.6 a	12.6 a	3.0 a	29.6 a	1.20 a
Micropropagated	83.3 a	19.3 b	1.9 b	6.1 b	0.8 b	3.7 b	0.37 b

Different letters within a column indicate significant treatment differences ($P \leq 0.05$).

Table 3.3.1.2. Effect Of Site On Survival And Growth Of Saskatoon Transplants, Keeler & UofS, 2000.

Site	Fall Survival (%)	Mean Height/Plant (cm)	Mean Number of Branches/Plant	Mean New Growth/Plant (cm)	Mean Number of Suckers/Plant	Mean Cumulative Sucker Length/Plant (cm)	Mean Sucker Length/Plant (cm)
UofS	88.3 a	31.1 a	3.2 a	10.2 a	2.5 a	19.1 a	1.0 a
Keeler	87.5 a	20.1 b	2.3 b	8.5 a	1.2 b	14.2 a	0.6 b

Different letters within a column indicate significant treatment differences ($P \leq 0.05$).

Table 3.3.1.3. Effect Of Cultivar On Survival And Growth Of Saskatoon Transplants, Keeler & UofS, 2000.

Cultivar	Fall Survival (%)	Mean Height/Plant (cm)	Mean Number of Branches/Plant	Mean New Growth/Plant (cm)	Mean Number of Suckers/Plant	Mean Cumulative Sucker Length/Plant (cm)	Mean Sucker Length/Plant (cm)
Northline	88.8 ab	23.0 a	2.6 ab	7.4 b	2.0 a	11.1 b	0.6 b
Smoky	93.8 a	28.7 a	3.2 a	12.6 a	2.8 a	34.1 a	1.2 a
Thiessen	81.3 b	25.0 a	2.4 b	8.0 b	0.8 b	4.7 b	0.5 b

Different letters within a column indicate significant treatment differences ($P \leq 0.05$).

Table 3.3.1.4. Effect Of Site And Cultivar On Sucker Production, Keeler & UofS, 2001.

Site	Cultivar	Mean Number of Suckers/Plant
Keeler	Northline	1.58 a
	Smoky	3.92 b
	Thiessen	1.86 a
UofS	Northline	9.98 d
	Smoky	9.65 d
	Thiessen	5.18 c

Different letters within a column indicate significant treatment differences ($P \leq 0.05$).

Table 3.3.1.5. Interaction Of Site And Propagation Method On Sucker Production, Keeler & UofS, 2001.

Site	Propagation Method	Mean Number of Suckers/Plant
Keeler	Micropropagated	1.30 a
	Seedling	3.62 b
UofS	Micropropagated	4.86 b
	Seedling	11.68 c

Different letters within a column indicate significant treatment differences ($P \leq 0.05$).

Table 3.3.1.6. Interaction Of Propagation Method And Cultivar On Sucker And Flower Production, Keeler & UofS, 2001.

Propagation Method	Cultivar	Mean Number of Suckers/Plant	Mean Number of Flowers/Plant
Micropropagated	Northline	4.07 b	0 a
	Smoky	3.08 ab	0 a
	Thiessen	2.08 a	0 a
Seedling	Northline	7.49 c	0.2 a
	Smoky	10.5 d	9.6 b
	Thiessen	4.96 b	0.1 a

Different letters within a column indicate significant treatment differences ($P \leq 0.05$).

Table 3.3.1.7. Interaction Of Site, Propagation Method And Cultivar On Stem Caliper, Height And Sucker Growth, Keeler & UofS, 2001.

Site	Propagation Method	Cultivar	Mean Stem Caliper/Plant (mm)	Mean Height/Plant (cm)	Mean Cumulative Sucker Length/Plant (cm)	Mean Sucker Length (cm)
Keeler	Micropropagated	Northline	5.24 a	16.3 ab	9.00 a	8.88 ab
		Smoky	5.34 a	20.3 ab	22.0 a	14.1 c
		Thiessen	4.26 a	10.3 a	10.2 a	7.23 a
	Seedling	Northline	5.91 ab	25.3 b	24.2 ab	11.6 b
		Smoky	8.74 cd	41.6 c	179.9 c	28.0 d
		Thiessen	6.30 b	27.7 b	36.4 ab	15.1 c
UofS	Micropropagated	Northline	6.44 b	24.6 b	40.3 ab	4.84 a
		Smoky	8.00 bc	48.7 cd	79.0 b	16.1 c
		Thiessen	6.91 b	32.0 b	39.5 ab	13.9 b
	Seedling	Northline	10.0 d	50.3 cd	228.8 cd	17.8 c
		Smoky	8.95 cd	49.5 cd	276.1 d	18.6 c
		Thiessen	10.1 d	54.4 d	106.7 b	13.2 bc

Different letters within a column indicate significant treatment differences ($P \leq 0.05$).

Table 3.3.2.1. Effect Of Transplant Type On Survival And Growth Of Saskatoon Transplants, Keeler & UofS, 2000.

Plug	Spring Survival %	Fall Survival %	Mean Number of Branches/Plant	Mean Height/Plant (cm)	Mean New Growth/Plant (cm)	Mean Number of Suckers/Plant	Mean Cumulative Sucker Length/Plant (cm)	Mean Sucker Length/Plant (cm)
Plug	75.6 a	60.0 a	2.4 a	27.5 a	10.9 a	0.48 a	19.0 a	3.9 a
Bare-root	72.2 a	49.7 b	1.8 b	20.5 b	6.1 b	0.19 b	5.3 b	1.7 b

Different letters within a column indicate significant treatment differences ($P \leq 0.05$).

Table 3.3.2.2. Effect Of Site On Survival And Growth Of Saskatoon Transplants, Keeler & UofS, 2000.

Site	Spring Survival %	Fall Survival %	Mean Number of Branches/Plant	Mean Height/Plant (cm)	Mean New Growth/Plant (cm)	Mean Number of Suckers/Plant	Mean Cumulative Sucker Length/Plant (cm)	Mean Sucker Length/Plant (cm)
UofS	82.8 a	56.1 a	2.4 a	29.5 a	8.9 a	0.36 a	13.4 a	3.0 a
Keeler	65.0 b	54.6 a	1.7 b	18.6 b	8.4 a	0.32 a	11.3 a	2.7 a

Different letters within a column indicate significant treatment differences ($P \leq 0.05$).

Table 3.3.2.3. Effect Of Mulch Type On Survival And Growth Of Saskatoon Transplants, Keeler & UofS, 2000.

Mulch Type	Spring Survival %	Fall Survival %	Mean Number of Branches/Plant	Mean Height/Plant (cm)	Mean New Growth/Plant (cm)	Mean Number of Suckers/Plant	Mean Cumulative Sucker Length/Plant (cm)	Mean Sucker Length/Plant (cm)
No mulch	73.3 ab	56.3 a	1.7 a	21.0 a	7.8 a	0.48 a	17.8 a	2.5 ab
Plastic	69.6 b	44.6 b	2.7 b	32.2 b	10.9 b	0.30 a	14.7 a	4.4 a
Wood Chip	78.8 a	63.8 a	1.9 a	20.0 a	7.5 a	0.17 b	5.9 b	2.0 b

Different letters within a column indicate significant treatment differences ($P \leq 0.05$).

Table 3.3.2.4. Effect Of Transplanting Date On Survival And Growth Of Saskatoon Transplants, Keeler & UofS, 2000.

Month	Spring Survival %	Fall Survival %	Mean Number of Branches/Plant	Mean Height/Plant (cm)	Mean New Growth/Plant (cm)	Mean Number of Suckers/Plant	Mean Cumulative Sucker Length/Plant (cm)	Mean Sucker Length/I (cm)
May	76.4 b	75.7 a	1.7 b	19.3 c	7.1 a	0.18 bc	6.0 b	1.4 a
June	89.6 a	77.1 a	2.0 ab	24.3 ab	8.0 a	0.59 a	22.3 a	2.8 a
July	63.9 c	32.6 c	1.7 b	20.1 bc	9.5 a	0.35 ab	10.2 b	2.6 a
August	56.3 c	26.1 c	2.5 a	28.4 a	9.9 a	0.14 c	7.0 b	3.5 a
September	83.8 ab	52.8 b	2.6 a	28.3 a	9.2 a	0.41 ab	14.6 ab	4.1 a

Different letters within a column indicate significant treatment differences ($P \leq 0.05$).

Table 3.3.2.5. Effect Of Mulch Type On Transplant Survival And Height, Keeler & UofS, 2001.

Mulch Type	Fall Survival (%)	Mean Height/Plant (cm)
No Mulch	55.8 b	27.4 a
Plastic	43.8 a	39.6 b
Woodchip	62.9 b	24.3 a

Different letters within a column indicate significant treatment differences ($P \leq 0.05$).

Table 3.3.2.6. Effect Of Site On Transplant Height And Branching, Keeler & UofS, 2001.

Site	Mean Height/Plant (cm)	Mean Number of Branches/Plant
Keeler	20.2 a	1.1 a
UofS	40.1 b	5.5 b

Different letters within a column indicate significant treatment differences ($P \leq 0.05$).

Table 3.3.2.7. Interaction Of Site And Transplant Type On Plant Height, Keeler & UofS, 2001.

Site	Transplant Type	Mean Height/Plant (cm)
Keeler	Bare-root	16.7 a
	Plug	23.6 b
UofS		32.6 c
	Bare-root	47.5 d

Different letters within a column indicate significant treatment differences ($P \leq 0.05$).

Table 3.3.2.8. Interaction Of Site And Transplanting Date On Survival, Number of Branches And Dry Shoot Weights, Keeler & UofS, 2001.

Site	Month	Fall Survival (%)	Mean Number of Branches/Plant	Mean Dry Shoot Weight/Plant (g)
Keeler	May	47.2 b	0.9 a	8.2 a
	June	83.3 de	1.7 a	29.9 b
	July	44.4 b	0.9 a	10.2 a
	August	26.4 a	0.7 a	5.3 a
	September	45.8 b	1.3 a	15.9 ab
UofS	May	90.3 e	5.0 b	69.2 d
	June	70.8 cd	5.7 bc	39.0 bc
	July	22.2 a	2.3 a	10.8 a
	August	48.6 bc	7.3 c	37.8 bc
	September	62.5 c	7.0 c	46.9 c

Different letters within a column indicate significant treatment differences ($P \leq 0.05$).

Table 3.3.2.9. Interaction Of Mulch And Transplanting Date On Survival And Mean Sucker Length, Keeler & UofS, 2001.

Mulch	Month	Fall Survival (%)	Mean Sucker Length/Plant (cm)
No Mulch	May	75.0 cd	9.0 ab
	June	91.7 d	14.8 b
	July	31.3 ab	6.3 a
	August	39.6 b	6.8 a
	September	41.7 b	8.5 ab
Plastic	May	68.8 c	18.0 c
	June	52.1 bc	14.3 b
	July	22.9 ab	8.9 ab
	August	20.8 a	9.0 ab
	September	54.2 bc	15.8 b
Woodchip	May	62.5 c	5.1 a
	June	87.5 d	6.2 a
	July	45.8 bc	7.9 a
	August	52.2 bc	10.5 ab
	September	66.7 c	8.8 ab

Different letters within a column indicate significant treatment differences ($P \leq 0.05$).

Table 3.3.2.10. Interaction Of Transplant Type And Transplanting Date On Plant Height, Keeler & UofS, 2001.

Transplant Type	Month	Mean Height/Plant (cm)
Bare-root	May	24.6 ab
	June	22.9 a
	July	22.3 a
	August	21.1 a
	September	32.3 cd
Plug	May	31.0 bc
	June	34.6 cde
	July	33.8 cde
	August	40.4 e
	September	37.9 de

Different letters within a column indicate significant treatment differences ($P \leq 0.05$).

Table 3.3.3.1. Effect Of Transplant Type On Survival And Shoot Growth Of Saskatoon Transplants, Outlook, 2000.

Transplant Type	Fall Survival %	Shoot Weight (kg)					
		Mean Treatment Shoot Weight (fresh)	Mean Treatment Shoot Weight (dry)	Mean Surviving Shoot Weight/Plant (fresh)	Mean Surviving Shoot Weight/Plant (dry)	Mean Shoot Weight (fresh)	Mean Shoot Weight (dry)
Plug	71.3 a	0.857 a	0.471 a	0.221 a	0.120 a	0.171 a	0.093 a
Bare-root	59.3 a	0.644 b	0.347 b	0.187 a	0.101 a	0.129 b	0.070 b

Different letters within a column indicate significant treatment differences ($P \leq 0.05$).

Table 3.3.3.2. Effect Of Mulch Type On Survival And Shoot Growth Of Saskatoon Transplants, Outlook, 2000.

Mulch Type	Fall Survival %	Shoot Weight (kg)					
		Mean Treatment Shoot Weight (fresh)	Mean Treatment Shoot Weight (dry)	Mean Surviving Shoot Weight/Plant (fresh)	Mean Surviving Shoot Weight/Plant (dry)	Mean Shoot Weight (fresh)	Mean Shoot Weight (dry)
No Mulch	68.7 a	0.708 a	0.387 a	0.198 a	0.109 a	0.141 a	0.070 a
Black Plastic	62.0 a	0.793 a	0.431 a	0.209 a	0.112 a	0.158 a	0.086 a

Different letters within a column indicate significant treatment differences ($P \leq 0.05$).

Table 3.3.3.3. Effect Of Transplanting Date On Survival And Shoot Growth Of Saskatoon Transplants, Outlook, 2000.

Month	Fall Survival %	Shoot Weight (kg)					
		Mean Treatment Shoot Weight (fresh)	Mean Treatment Shoot Weight (dry)	Mean Surviving Shoot Weight/Plant (fresh)	Mean Surviving Shoot Weight/Plant (dry)	Mean Shoot Weight (fresh)	Mean Shoot Weight (dry)
May	90.0 a	1.348 a	0.733 a	0.323 a	0.176 a	0.268 a	0.148 a
June	83.3 a	1.258 a	0.689 a	0.278 a	0.153 a	0.253 a	0.137 a
July	48.3 b	0.492 b	0.276 b	0.176 b	0.098 b	0.098 b	0.056 b
August	50.0 b	0.333 b	0.173 b	0.149 bc	0.077 bc	0.066 b	0.034 b
September	55.0 b	0.323 b	0.173 b	0.093 c	0.050 c	0.065 b	0.034 b

Different letters within a column indicate significant treatment differences ($P \leq 0.05$).

Table 3.3.4.1. Interaction Of State of Dormancy and Transplanting Date On Saskatoon Transplant Survival And Growth, UofS 2001.

State of Dormancy	Transplanting Date	Fall Survival (%)	Mean Height/Plant (cm)	Mean New Growth/Plant (cm)	Mean Number of Branches/Plant
Dormant	May	62.5 a	24.4 a	18.5 a	1.0 a
	June	93.8 b	36.5 b	26.9 ab	1.9 a
	July	100 b	47.1 bc	41.4 c	1.2 a
	August	100 b	56.0 c	47.3 c	1.5 a
	September	100 b	58.6 c	49.3 c	1.3 a
Non-Dormant	May	100 b	36.3 b	25.3 ab	1.4 a
	June	100 b	27.3 ab	22.3 ab	1.0 a
	July	100 b	34.8 ab	28.0 b	0.9 a
	August	100 b	31.5 ab	23.6 ab	0.4 a
	September	93.4 b	42.1 b	34.8 bc	1.0 a

Different letters within a column indicate significant treatment differences ($P \leq 0.05$).

Figure 3.2.1. Saskatoon transplant study, September 1999, University of Saskatchewan, Saskatoon, SK.

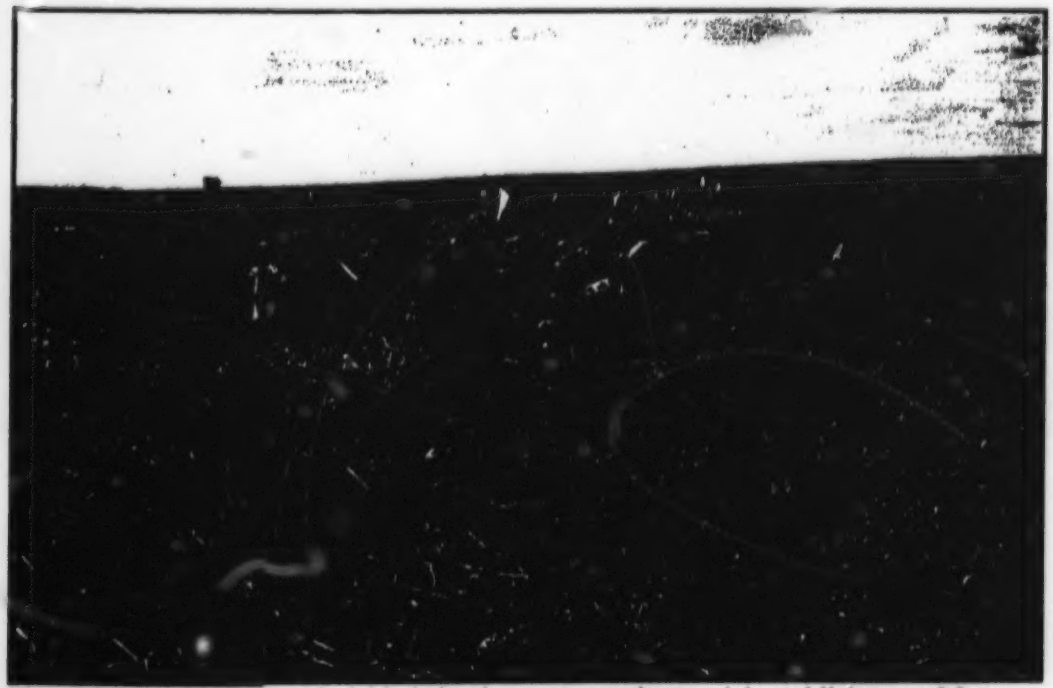


Figure 3.2.2. Installation of trickle irrigation system prior to trial establishment, May 1999, Keeler, SK.

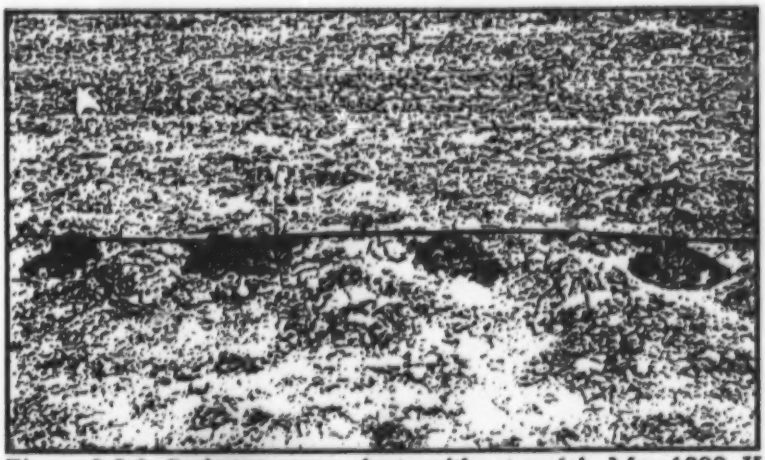


Figure 3.2.3. Saskatoon transplants without mulch, May 1999, Keeler, SK.

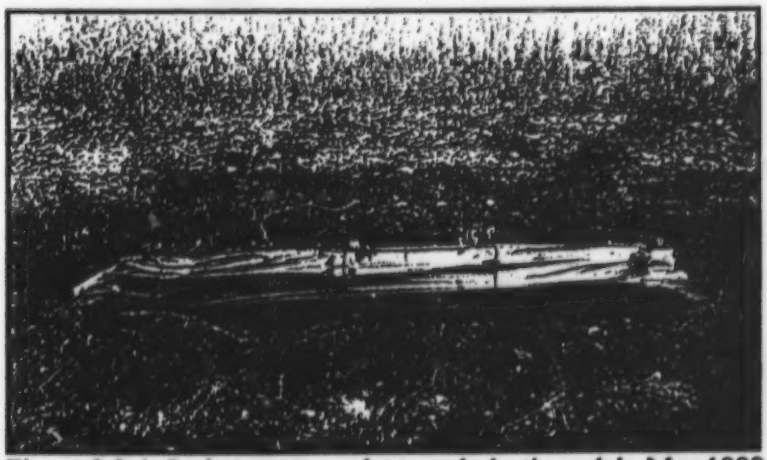


Figure 3.2.4. Saskatoon transplants and plastic mulch, May 1999, Keeler, SK.

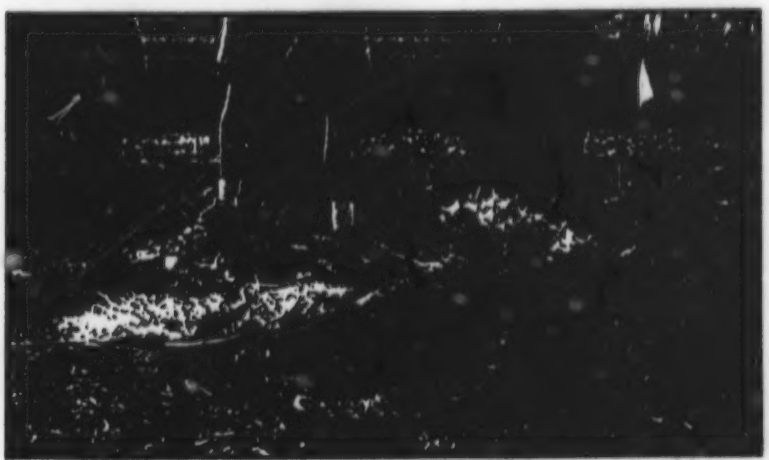


Figure 3.2.5. Saskatoon transplants planted in a trench with woodchip mulch, September 1999, University of Saskatchewan, Saskatoon, SK.

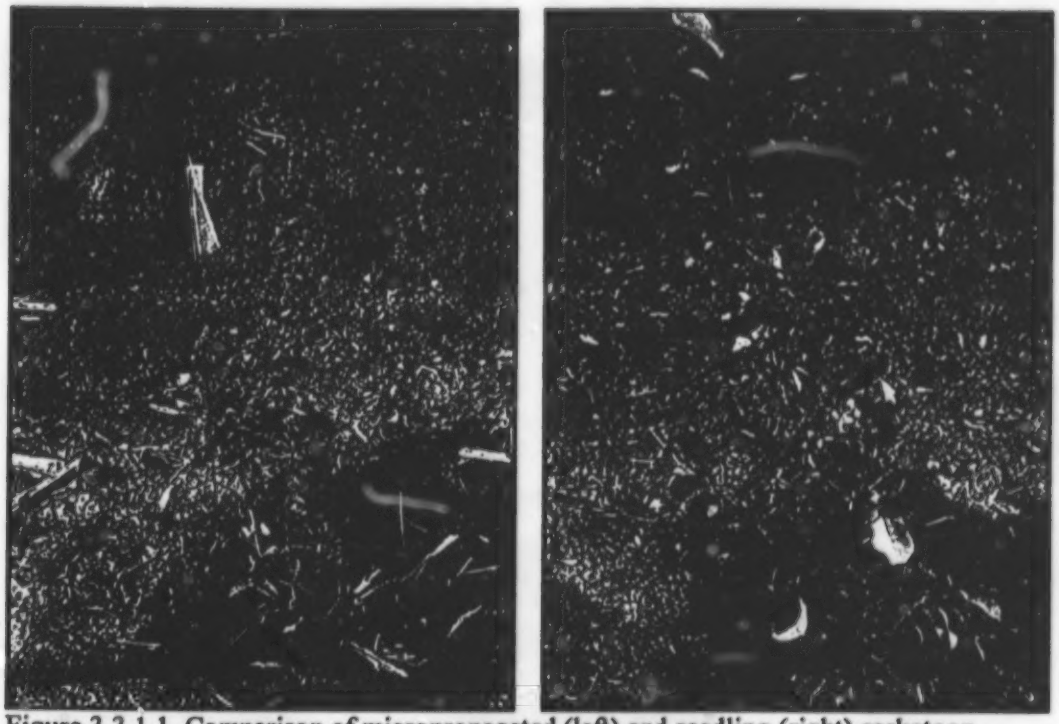


Figure 3.3.1.1. Comparison of micropropagated (left) and seedling (right) saskatoon transplants, University of Saskatchewan, August 2000.

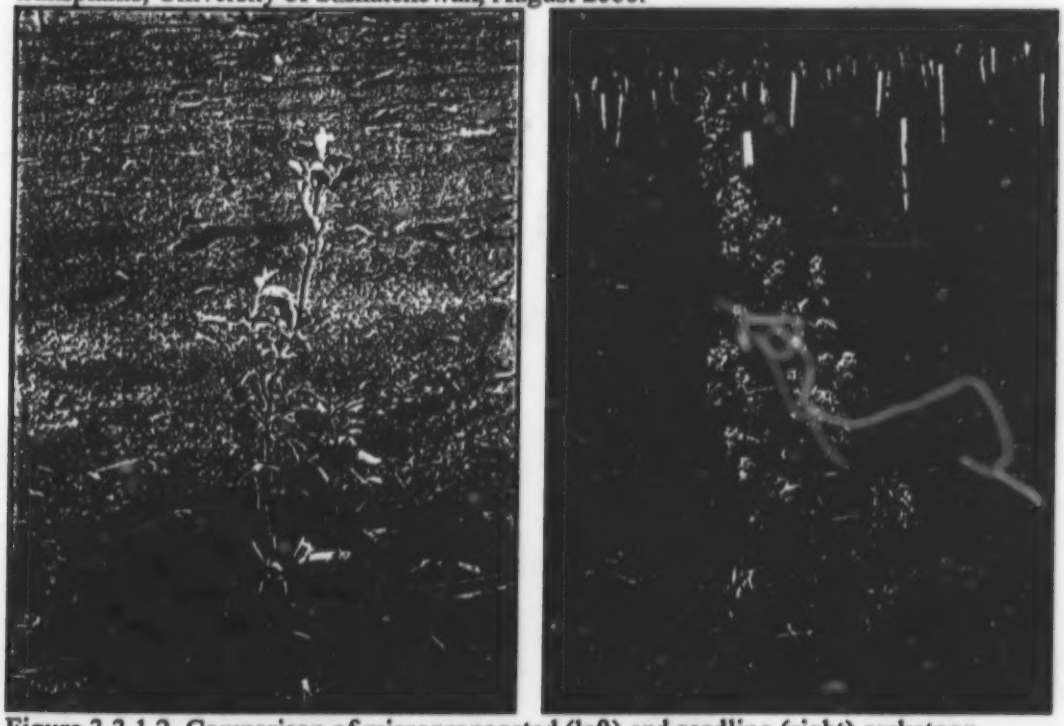


Figure 3.3.1.2. Comparison of micropropagated (left) and seedling (right) saskatoon transplants, University of Saskatchewan, May 2001.

Figure 3.3.2.1. Mean daily soil temperature, 15 cm below soil surface, 2001, University of Saskatchewan, Saskatoon, SK.

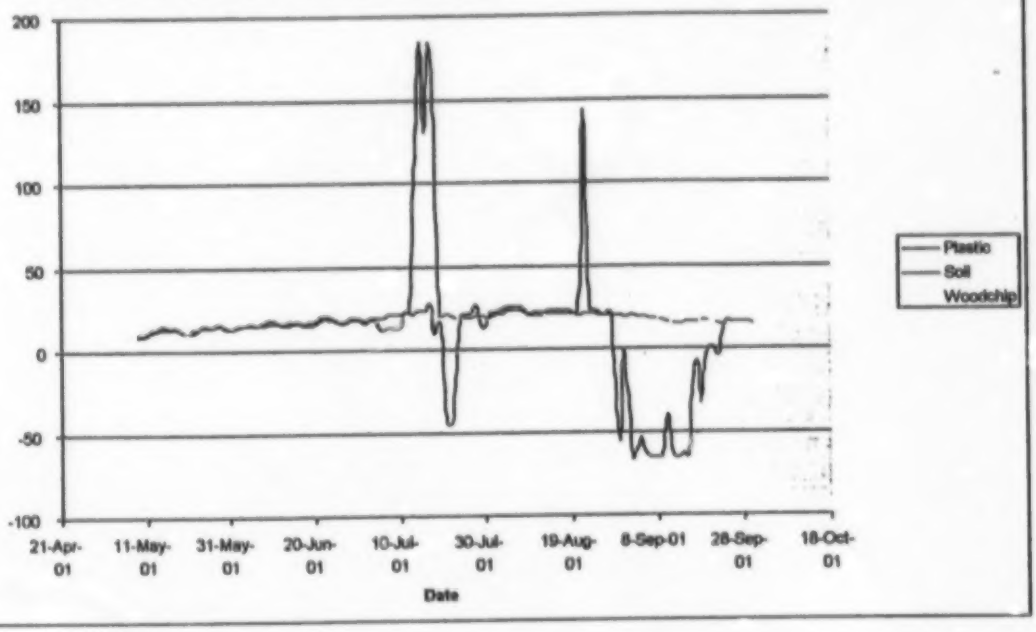


Figure 3.3.2.2. Mean daily soil temperatures, 15 cm below soil surface, May & June, 2001, University of Saskatchewan, Saskatoon, SK.

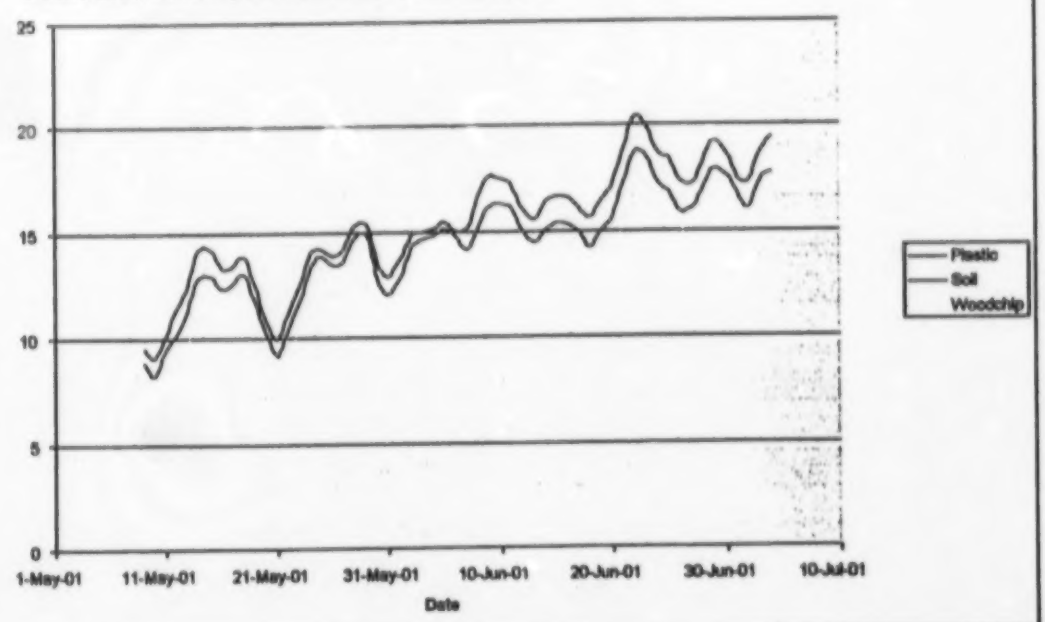


Figure 3.3.2.3. Mean daily soil temperature, 30 cm below surface, 2001, University of Saskatchewan, Saskatoon, SK.

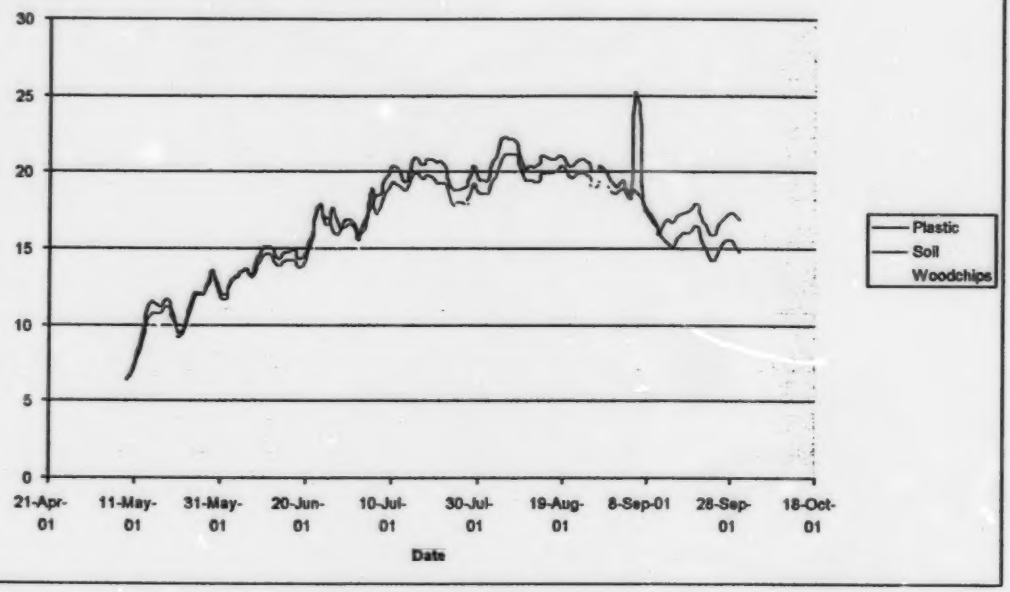


Figure 3.3.2.4. Mean daily soil moisture, 15 cm below soil surface, 2001, University of Saskatchewan, Saskatoon, SK.

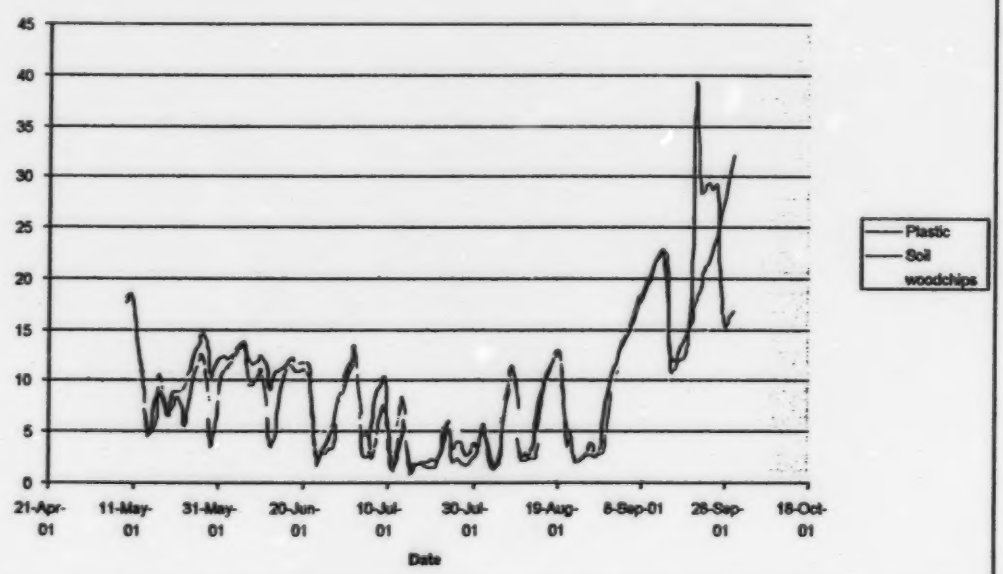
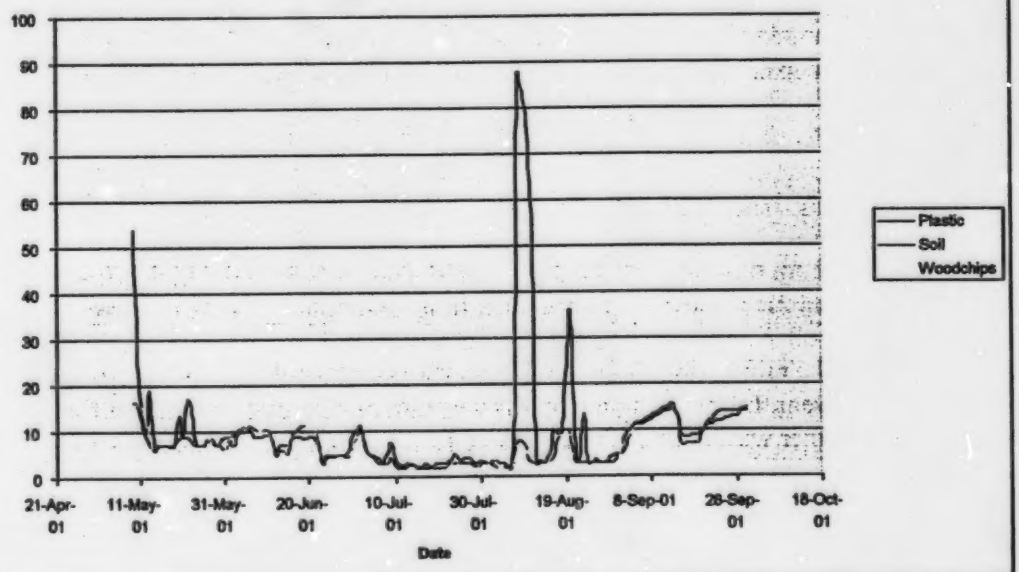


Figure 3.3.2.5. Mean daily soil moisture, 30 cm below soil surface, 2001, University of Saskatchewan, Saskatoon, SK.



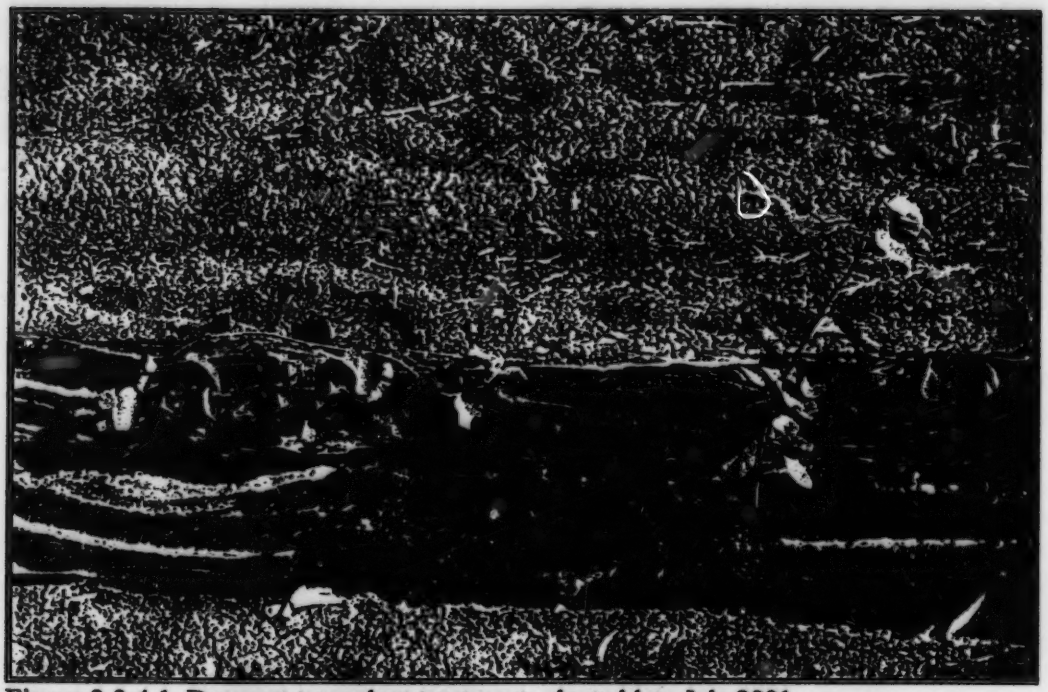


Figure 3.3.4.1. Dormant transplant treatment, planted late-July 2001.

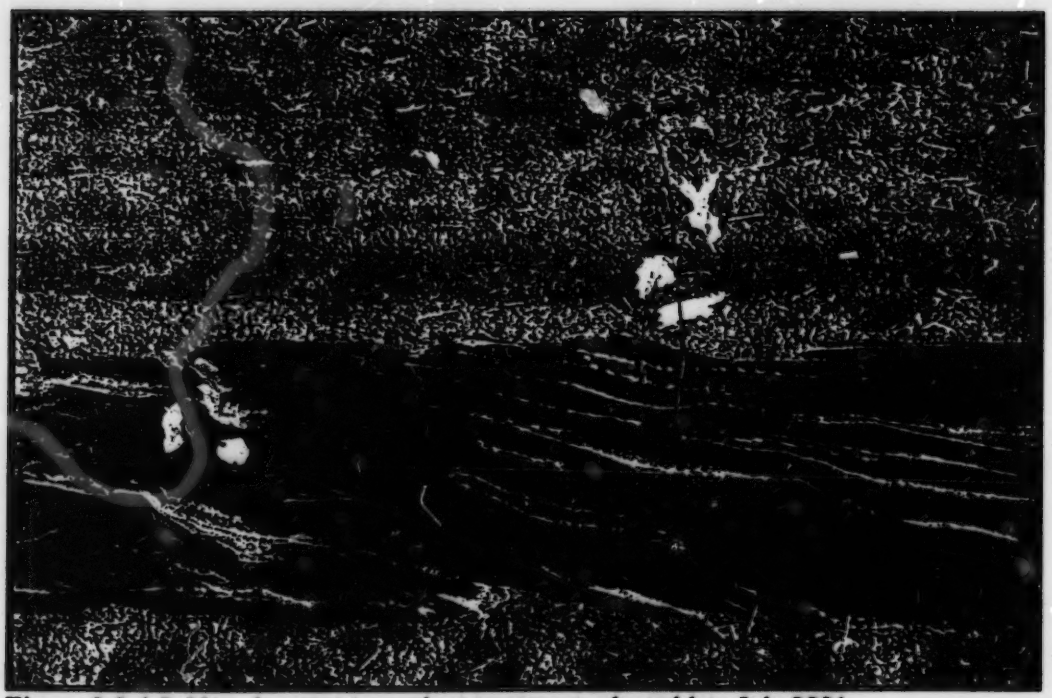


Figure 3.3.4.2. Non-dormant transplant treatment, planted late-July 2001.

4. PERSONNEL

R. St-Pierre - 5%
H. Tulloch - 15%
J. Hall - 20%
S. Anwender – 15%
L. Pilsner - 15%
M. Rude - 15%
M.Denille - 15%

5. EQUIPMENT

None purchased.

6. PROJECT DEVELOPED MATERIALS

Publications

R.G. St-Pierre and H. Tulloch. 2001. A Comprehensive Overview of Transplanting Saskatoons. The Prairie Fruit Journal 8(2):3-5.

Reports

R.G. St-Pierre, 2001. Maximizing Root Development for Enhanced Survival and Establishment of Newly-transplanted Saskatoons. Progress Report - February 15, for Saskatchewan Agriculture and Food, Agriculture Development Fund.

R.G. St-Pierre, 2000. Maximizing Root Development for Enhanced Survival and Establishment of Newly-transplanted Saskatoons. Progress Report - April 15, for Saskatchewan Agriculture and Food, Agriculture Development Fund.

R.G. St-Pierre, R.G. 1999. Maximizing Root Development for Enhanced Survival and Establishment of Newly-transplanted Saskatoons. Progress Report - October 15, for Saskatchewan Agriculture and Food, Agriculture Development Fund.

R.G. St-Pierre, 1999. Maximizing Root Development for Enhanced Survival and Establishment of Newly-transplanted Saskatoons. Progress Report -April 15, for Saskatchewan Agriculture and Food, Agriculture Development Fund.

7. PROJECT PHOTOS

Included with report.

8. ACKNOWLEDGEMENT

Publications

R.G. St-Pierre and H. Tulloch. 2001. A Comprehensive Overview of Transplanting Saskatoons. The Prairie Fruit Journal 8(2):3-5.

Reports

R.G. St-Pierre, 2001. Maximizing Root Development for Enhanced Survival and Establishment of Newly-transplanted Saskatoons. Progress Report - February 15, for Saskatchewan Agriculture and Food, Agriculture Development Fund.

R.G. St-Pierre, 2000. Maximizing Root Development for Enhanced Survival and Establishment of Newly-transplanted Saskatoons. Progress Report - April 15, for Saskatchewan Agriculture and Food, Agriculture Development Fund.

R.G. St-Pierre, R.G. 1999. Maximizing Root Development for Enhanced Survival and Establishment of Newly-transplanted Saskatoons. Progress Report - October 15, for Saskatchewan Agriculture and Food, Agriculture Development Fund.

R.G. St-Pierre, 1999. Maximizing Root Development for Enhanced Survival and Establishment of Newly-transplanted Saskatoons. Progress Report -April 15, for Saskatchewan Agriculture and Food, Agriculture Development Fund.

9. EXPENSE STATEMENT

Sent under separate cover by Research Accounts, University of Saskatchewan.